Progress Report

Engaging Agricultural Communities in the Great Plains of the United States with the Applications and Developments of Climate Prediction and Information

(NOAA Project GC02-181)

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I. Preliminary Materials

A. Project Abstract

This proposal details a plan by researchers at the University of Nebraska-Lincoln to conduct a series of workshops and surveys, and develop and analyze a decision-behavioral model to understand: (1) how the effects of climate variability are perceived as represented in climate forecasts and products used by producers in three agroecozones representing different grain production regimes, rainfed, irrigated, and a mix of both in the western Corn Belt/eastern Nebraska area; (2) what are the attributes entering producers' thinking and their interplay to formulate producers' intentions and decision to act on and use or not use climate forecasts; and (3) how we can improve climate education and accordingly modify climate forecasts and products so to increase the effect of climate forecasts in farmer's thinking and decision-making. The goals are to raise the value of climate forecasts and products and, thus, climate research in the agricultural communities in the Great Plains, with the goal of reducing their vulnerability to climate risks in a changing environment.

The specific objectives of the project are to: (1) identify those agricultural activities most sensitive to climate variability in the study area and determine how the application of climate forecasts and products (or improved products) would help producers optimize production and profit; (2) develop evaluation devices and methods to gather information and understand those factors that agricultural producers consider when making decisions with climate products, relative to their farm landscape and inherent climate variability and those social, environmental, and economic constraints that affect the way producers formulate climate forecasts in making their decisions; (3) use materials gathered in (2) and develop a model that will quantify the probability for producers to act, and the extent to which they act, due to climate products influencing their decisions; and (4) develop a continuous monitoring system to update our understanding of the evolution of producers' thinking process over time, particularly, changes in the probability of using climate forecasts/products and their perception of the use of these products in their decisions after major climate events. This system will provide data to update the model developed in (3) and from this analysis to find adjustments for climate predictions and ways to improve predictions. This system can be used as a protocol for expanding this methodology into other counties in Nebraska and other states in the Great Plains region.

These objectives and goals are attainable in the proposed time frame because of existing substantial understanding of the agroecozones in the region and the characteristics of the farmers' communities. We have accumulated experience in successfully conducting surveys and workshops of various scales, and also have developed decision and behavioral models. With the basis of good understanding of the problem, our integration of multidisciplinary knowledge and experience warrant a successful project.

B. Specific Objectives of This Project

1. To identify the two prerequisites discussed previously for representative counties in the three agroecozones (i.e., the agricultural activities in these areas mostly impacted by climate variation/anomaly), and skillful climate forecasts/products that, after proper use or improvement and use, will provide producers with better tools to capitalize on favorable climate conditions or reduce the impacts of adverse climate conditions to optimize production and profit.

2. To develop evaluation devices and methods to gather information and understand those factors that producers consider when making decisions with climate products, relative to their farm landscape and inherent climate variability and those social, environmental, and economic constraints that affect the way producers formulate climate forecasts in making their decisions.

3. To use materials gathered in 2) and develop a model that will quantify the extent to which the producers will act on using various climate products (e.g., 60-day or 90-day forecast) and complete a particular task (e.g., to plant a drought resistant crop like sorghum or to purchase a particular variety or combination of varieties [fast maturing variety vs. high yield variety] of corn for the next growing season).

4. To develop a continuous monitoring system to update our understanding of the evolution of producers' thinking process over time, particularly, changes in the probability of using climate forecasts/products and their perception of the use of these products in their decisions after major climate events. This system will provide data to update the model developed in (3) and from this analysis to find adjustments for climate predictions/ products and ways to improve them. This information will help engage producers in using these predictions. This system can be used as a protocol for expanding this methodology into other counties in Nebraska and other states in the Great Plains region.

C. Approach

There are two steps in taking an action with regard to using climate forecasts/information in agricultural decisions. First, farmers form an intention to use a forecast and, second, carry out the intention. We will refer to this two-step process as the decision-making process. It involves weighing many factors. They can be categorized into four groups: 1) the pursuit of self-interest, 2) the pursuit of other-interest, a kind of community or common interest, 3) political and physical environmental constraints and outside influences, and the personal ability to do, and 4) the biophysical situation represented in a particular agroecozone. By weighing these factors, an intention is formed in a person's mind to take an action. Whether this intention is executed as an economic action depends on further evaluation of personal ability and capability.

Climate forecasts are one of the factors and it has three attributes in this decision-making: 1) it provides a possible future physical environment the farmer's operation will be in, 2) a farmer can benefit from forecasts but needs adequate knowledge and skill to understand and use them, and 3) forecasts have intrinsic uncertainties and, therefore, consequences the farmer should consider. Also, there is a community dimension in using forecasts, in that others in the communities laying claim on a producer's actions may not see forecasts as useful tools. It remains unknown as to how the self and community (others) interest interacts, and how outside influences affect producers' thinking and decision-making, and, in conjunction with abilities, affect actual action. We will provide insights on this question and quantitative tools to measure how farmers in the study areas develop their intention to use or not use climate forecasts in making their farming decision and what factors raise the probability for them to take actions of using this information. We will develop and analyze a decision-behavioral model building on previous work by principal investigators of this project and others. Mathematically, if we posit $I_S(A; L)$ reflecting a farmer's self-interest in applying a climate forecast, L, with ability, A (e.g., his/her knowledge and skill of using climate forecasts), $I_C(A; L)$ the farmer's community-interest in using the same forecast in a decision, $I_A(L; A)$ the interest in the outside influence and ability factor associated with using the specific forecast L, and influence of the biophysical situation on a farmer's intension to use L, $I_Z(L; Z)$, our theories interpret that the possibility for the farmer to decide *and* use L may be determined by:

$$\begin{aligned}\Phi = {} & B_S I_S(A;L) + B_C I_C(A;L) + B_A I_A(L;A) + B_Z I_Z(L;Z) + B_D[I_S \times I_C] + \\ & B_1[I_A \times I_S] + B_2[I_A \times I_C] + B_3[I_Z \times I_A] + B_4[I_Z \times I_B] + B_5[I_Z \times I_C] + \varepsilon.\end{aligned} \tag{1}$$

In (1), Φ is the probability of taking an action, and the coefficients, B, weigh the effect of each factor and their interaction on intent and actual action. To develop this model, we will use survey methods to gather information and determine the coefficients in (1) using a least-square regression method along with variance analysis.

The survey questions will be designed based on the theoretical framework of Ajzen and Fishbein to obtain adequate information on attributes entering agricultural producers' decision-making and for determining the coefficients in (1). These questions will be brought to focus group meetings and workshops in study counties and revised and amended for both easy understanding for producers and accuracy in describing the relevant decision processes. After finalizing the survey, we will conduct a mail survey in study counties in different agroecozones. Answers to survey questions will be analyzed to develop the model (1). After the model is developed, it will be analyzed to understand what role climate forecast has played in farming decisions, and what may be changed, e.g., improving agricultural producers' ability of interpreting forecasts and/or imposing policies favoring producers' use of climate forecasts, in order to raise the frequency of using forecasts and using them correctly in decisions.

Because thinking is a dynamic process, producers' intention of using or not using climate forecasts and their perception of climate effect changes with time as personal knowledge, information technology, and forecast skills improve. It is important to know how each of these attributes influences a producer's decision-making so that future effective programs can be developed to improve use of climate forecasts and information. For this reason, we will develop an Internet survey tool, which will be used repeatedly on annual basis to monitor and understand decision-making related to use of climate forecasts.

D. A Description of Matching Funds Used for This Project

Collaborative Interdisciplinary Projects

Spurred by this NOAA project, this research team also received multiple awards from the National Science Foundation and USDA Risk Management Agency to construct new geospatial decision support systems that can help farmers to make decisions regarding cropping and tillage systems and given drought scenarios. The research of this NOAA project directly supports efforts in building drought management decision support systems that farmers, University Cooperative Extension, agribusiness, and USDA agencies can use to evaluate current and historical drought events, as documentation to crop insurance claims and mitigation of high risk regions. The listening forums provided "rules of thumb" that the farm community follows in planning and mitigating events. In addition, the farmer discussions identified the sources of climate information, types of analyses that are understood and relied upon, and the information needs given changes in management practices and technology. The research into human behavior, attitudes, and beliefs as they relate to climate information, has led to major changes in the design, types of geospatial analyses, and delivery paths of the other projects. Collectively, this NOAA project has been matched with $2.5 million in competitive grants through the efforts of this research team.

The National Science Foundation (NSF) Digital Government Program has provided this research group with an award to support drought research in collaboration with the USDA Risk Management Agency (RMA) that will be implemented in Nebraska and the Great Plains. The award provided funding of $498,533, $249,589, and $259,972 over three years, beginning in July 2003. We believe that components (drought index models and vulnerability mapping) of the NSF supported research will be transferable in developing the drought and fire-monitoring framework for the selected national monuments and parks. The drought index models (SPI, PDSI, and the NSM) provide multiple time windows to evaluate the intensity and magnitude of events, which translates into map products that can represent near real-time conditions and the historical climate context (often back to the 1890's for Nebraska weather stations). These drought index tools can be found at our web page: http://nadss.unl.edu.

In addition to the NSF Digital Government Program, this research group received an award from the USDA Risk Management Agency to support "Risk Assessment and Exposure Analysis on the Agricultural Landscape--A Holistic Approach to Spatio-Temporal Models and Tools for Agricultural Risk Assessment and Exposure Analysis." This project was funded for $1.3 million over 2 years and provides for the development of drought risk assessment tools tailored to farmers and ranchers, as well as USDA/RMA crop insurance programs.

This research group also has received another award from NSF's Information Technology Research program for a project entitled "Intelligent Joint Evolution of Data and Information: An Integrated Framework for Drought Monitoring and Mitigation Support". This project has been funded for two years with a total award of $200,000 to build an integrated hydrological drought (stream gauges, lake stages, and groundwater wells) framework that views droughts through various windows that can provide higher resolution, better detect emergence and closure of events, as well as their spatio-temporal impacts. A key outcome of this project is the integration of National Weather Service and High Plains Regional Climate Center weather station networks, USGS stream gage and groundwater monitoring sites, and USDA geospatial natural resource databases into a coherent picture of hydrologic drought in the Great Plains and impacts on natural ecosystems.

Other Matching Funds

Several project members have devoted more than double of their time originally budgeted for the project. The salary and fringes from the extra time put on the project may be considered as matching funds. In addition, our secretaries have provided a great deal of support to this project for no pay from it. Their time and associated salary and fringe also are matching funds of this project.

II. Interactions

A. Interactions with Decision Makers (who were either impacted or consulted as part of this study)

This project period was devoted to understanding the survey data and to developing the decision-making models and no organized focus group was conducted. Only one climate education workshop was organized on March 18, 2004 in Grand Island, Nebraska, to share some findings from the survey and workshops of this and other related projects. The workshop was satellite broadcasted statewide and some of the video clips can be found at the following addresses.

Climate Education Program Workshop, March 18, 2004, NU Ext. Center, College Park, Grand Island, Neb.

- ----Opening Remarks
  http://g2.unl.edu:8080/ramgen/programs/misc/ceep1-031804.rm?start=00:00:02&end=00:08:09
- ----How has El Nino Affected Growing Season Rainfall in Nebraska?
  http://g2.unl.edu:8080/ramgen/programs/misc/ceep1-031804.rm?start=00:08:24&end=00:020:53
- ----El Nino Followup Questions for Steve Hu
  http://g2.unl.edu:8080/ramgen/programs/misc/ceep1-031804.rm?start=01:18:20&end=01:31:48
- ----Crop Insurance Issues in Multiyear Droughts
  http://g2.unl.edu:8080/ramgen/programs/misc/ceep1-031804.rm?start=00:21:30&end=01:18:15
- ----Weather and Climate Information and Resources for Nebraska...
  http://g2.unl.edu:8080/ramgen/programs/misc/ceep1-031804.rm?start=01:32:40&end=01:55:05
- ----Use of Climate Information in Irrigation Management
  http://g2.unl.edu:8080/ramgen/programs/misc/ceep1-031804.rm?start=01:55:37&end=02:42:54
- ----Drought Outlook and Mitigation Methods in Agriculture
  http://g2.unl.edu:8080/ramgen/programs/misc/ceep2-031804.rm?start=00:00:00&end=00:34:36
- ----Summary of Recent Surveys on Nebraska Farmers' Needs on Weather & Climate Info.
  http://g2.unl.edu:8080/ramgen/programs/misc/ceep2-031804.rm?start=00:34:54&end=01:08:38
- ----Panel Discussion & Closing Remarks
  http://g2.unl.edu:8080/ramgen/programs/misc/ceep2-031804.rm?start=00:00:24&end=01:42:00

B. Interactions with the Climate Forecasting Community

Continued effort was put in contacting the NOAA CPC forecasters. CPC's. Discussions on visit of the CPC has been in discussion.

C. Coordination with other projects of the NOAA Climate and Societal Interaction Division

No activity has been engaged in this area.

III. Accomplishments

A. Research Tasks Accomplished

Two major tasks were accomplished in this 10-month period and they are detailed in the following.

a) Modeling study

The main focus of the project proposal pointed to further testing the "theory of planned behavior" as first proposed by Ajzen (1991). It was proposed to do this test in the context of farmer's use of weather forecasts and information. Substantive progress has been made.

Model

Ajzen (1991) suggested that all intentions and the behaviors resulting from said intentions could be explained by three variables, attitude, social pressure or norms, and perceived behavioral control. In our case, behavior is represented by the degree of influence of weather information and forecasts on a farmer's intentions (I) and actual behavior (B) in crop related decisions. The first decision-making component, attitude, is the product of the probability of the action being taken as measured by the belief (b_i) that a certain action will lead to some outcome and value that is placed on this outcome (e_i). The second component, social norms, is a belief (n_j) about what others believe the appropriate action might be multiplied by the value of complying with these other perceptions (m_j). The third component, perceived behavioral control, represents a kind of constraint on the individual reflected in various beliefs (c_k) and the preference for complying (p_k). Thus the overall model becomes:

$$B \sim I = \beta_1 \sum_{i=1}^{s} b_i e_i + \beta_2 \sum_{j=1}^{t} n_j m_j + \beta_2 \sum_{k=1}^{v} c_k p_k$$

This model generally fits within the class known as expectancy-value models, involving a "belief" and a "value" component that is multiplied together in each case. In economic terms, this is a measure of "experienced utility" (after Kahneman, 1997), with the attitude construct akin to the notion of utility in economics (Vedopivec, 1992). As Ajzen (2002) indicates, "vexing problems remain" in the model, especially in the third term addressing control, as has been borne out in testing in the context of weather forecasts and information.

Data and development of the statistical models

In January 2003, 2100 farmers from Seward, Otoe, and Fillmore counties in Nebraska received surveys, and 724 or 33% of those responded. The final dataset contains 698 valid observations across all three counties. Correlation analysis testing internal consistency of survey questions suggests that farmers interpreted them correctly.

The Bagozzi (1984) test and Principal Component Analysis were used to form the three independent variables in the previous equation. These tests indicated that farmers viewed the influence of weather forecasts on their agronomic, insurance, and marketing decisions differently, suggesting the need for at least three different probability models, one for each of these three types of decisions. Also, the influence of short-term forecasts in concert with farmer's recent and past experience was found significantly different from the influence of the long-term forecasts for agronomic (spring, summer, and fall) decisions, suggesting that the agronomic decisions had to be further segmented as between the recent past/short-term forecasts situation and the long-term. In contrast, farmers considered the influence of their recent and past experience, short-term and long-term weather and climate forecasts on insurance and crop marketing decisions equally important, so the temporal dimension of the forecast information for these two decision types could be handled as one kind of influence. The overall result is four probability models, with two in the agronomic decisions area (with different time frames on the forecasts, basically the short-term vs. the long-term), and one each in the decision making arenas of crop insurance and marketing.

Analysis and discussion

Due to the probability nature of the behavioral variable, statistical analysis involved applying Logit and Tobit statistical procedures. That is, we estimate the probability that farmers are influenced or not (0,1 as in a Logit or 0,X as in a Tobit), and, then, if they are influenced, the extent to which they are influenced (the X in the Tobit). The relative statistical robustness of both models was then compared, with Tobit-based models generally producing more robust results than did the Logit model. This suggests 1) there are two groups of farmers, those who are not influenced by weather forecasts and information, and 2) for those who are influenced, there is substantive variability in the extent to which they are so influenced. Both the Logit and Tobit based models are shown in Table 1.

Table 1. Comparison of the LOGIT and TOBIT Analysis of the Influence of Weather Forecasts on Nebraskan Farmers' Decisions Using Theory of Planned Behavior.

Explanatory Variables	Agronomy (Cur. Rec. Past & STF)				Agronomy (LongTermForecasts)				Insurance				Marketing			
	Logit		Tobit		Logit		Tobit		Logit		Tobit		Logit		Tobit	
	t-value	Adj.R2	t-value	Adj.R2	t-value	Adj.R2	t-value	Adj.R2	t-value	Adj.R2	t-value	Adj.R2	t-value	Adj.R2	t-value	Adj.R2
Dryland Farmers																
Attitude	**11.06**	61.65	**11.77**	57.27	**12.73**	59.60	**12.28**	60.05	**13.78**	70.60	**16.03**	66.39	**8.60**	45.05	**12.08**	45.67
Norms	**3.35**	**Deg.Frdm**	**3.39**	**Deg.Frdm**	**2.24**	**Deg.Frdm**	**2.04**	**Deg.Frdm**	0.43	**Deg.Frdm**	0.78	**Deg.Frdm**	1.51	**Deg.Frdm**	0.78	**Deg.Frdm**
Control	1.19	31.	**3.39**	33/284	**1.70**	318	**3.93**	43/279	1.64	320	0.82	109/215	-0.35	323.	0.69	77/250
Irrigating Farmers																
Attitude	**1.81**	13.50	**6.93**	32.52	**5.04**	35.09	**9.44**	41.50	**7.14**	47.00	**11.50**	50.70	**8.08**	41.40	**9.01**	33.50
Norms	1.53	**Deg.Frdm**	**2.67**	**Deg.Frdm**	-0.46	**Deg.Frdm**	0.73	**Deg.Frdm**	-0.43	**Deg.Frdm**	0.24	**Deg.Frdm**	-0.46	**Deg.Frdm**	**1.96**	**Deg.Frdm**
Control	0.75	238	**2.06**	3/239	1.47	241.	**2.72**	15/230	1.19	238.	0.79	56/186	-0.97	239.	0.92	15/228
Integrated across Dryland and Irrigated Farmers' Datasets																
Dummy	**1.57**	51.90	**1.41**	50.65	**0.42**	52.42	**0.71**	54.05	**-1.18**	61.70	**1.54**	60.45	**3.73**	49.20	**3.70**	44.70
Attitude	**9.29**		**13.74**		**11.47**		**15.56**		**14.73**		**19.80**		**12.05**		**15.33**	
Norms	**4.12**	**Deg.Frdm**	**4.51**	**Deg.Frdm**	**1.70**	**Deg.Frdm**	**2.23**	**Deg.Frdm**	-0.18	**Deg.Frdm**	0.75	**Deg.Frdm**	1.29	**Deg.Frdm**	**1.79**	**Deg.Frdm**
Control	1.57	550.	**4.06**	36/519	**2.34**	558	**4.86**	58/505	**1.86**	557	1.11	164/398	-0.70	561	1.53	92/474

Focusing on the Tobit model result in Table 1, the most notable feature of the result is the robust t-test statistics on the Attitude construct: It is never lower than about $t = 5$ and ranges upwards of $t = 20$, suggesting probability $p < 0.01$ at minimum. Such large t-statistics suggest even higher significance in many cases, suggesting robust support for the Ajzen model.

It is especially striking that the Norms variable in Table 1 is so statistically strong in the agronomic decisions. This suggests that farmers are buying into norms for use of weather information in the communities of interest, and are being influenced by others. Perceived social norms play the largest role in agronomic decisions, which is logical. For example, a farmer may consult with his friends, family, or bankers to make a final decision of planting certain type of crop or selecting a planting date "to go with the flow." At the same time, the effect of perceived social norms disappears in marketing and insurance decisions. These kinds of decisions seem to be more individualized, perhaps more profit oriented, with the influence of others quite minimal.

Those seeking more control over their operations and working hard to obtain more ability and control in its application also tend to let it influence the agronomic decisions. Farmers perceive control as a limiting factor in agronomic decisions. This is not the case in the insurance and marketing decisions, with control not a substantive factor in explaining the influence of weather forecasts on the influence of insurance and cropping decisions. This may be due to the fact that once the crop has been harvested it really is not affected much by weather forecasts (albeit such forecasts in another country seemingly could affect the marketing… when to sell.. decision). Also, the very act of buying crop insurance is to protect oneself from uncertain weather, which probably explains why the control variable is not a significant variable for the insurance decision. We continue to explore how this control variable is operating in the farming community. As Ajzen (2002) suggests, we may need to try alternative conceptions of it, especially sorting out how ability (self-efficacy) plays into perceived behavioral control.

Overall, the theory of planned behavior modeling has been on schedule. Also, it appears that the theory will be well supported by the data of our survey, which also suggest that the theory and the approach we have proposed and taken may be a viable choice in predicting the use and influence of weather forecasts and information.

b) Identify demographic and environmental influence on decision behaviors

The Ajzen model developed and described in a) reveals a "global relationship" of those factors influencing decisions and farmers intention to use climate forecast and information in decisions. Although this global relationship is robust in different environment, some factors may play a more or less significant role in decision-making. This variation reflects interactions of human and natural environment and is the very reason that we have proposed to study the three counties (instead of one) with rather different cropping environments. In identifying the factors attributing to differences in decision behavior we focused on demographic and environmental, specifically access to irrigation, effects. Table 2 shows an example of our analyses and summarizes the similarity and differences of intention and use of forecasts in various decisions. The note under Table 2 provides interpretation of the results.

B. List of Papers and Publications

We have submitted to the *Bulletin of the American Meteorological Society* the following two manuscripts in February 2004 (copies of the manuscripts are enclosed in this report). Both are in review. We have received comments and suggestions from the Chief Editor of the journal on the survey paper and are currently revising it. Two additional manuscripts are being drafted: one is on the Ajzen model for this decision-making problem and the other on perceivedness of climate forecasts by farmers and the factors that predict the farmers' decision behavior related to using or not using climate forecasts.

C. Discussion of Significant Deviations

Our research in this period followed original plan without any significant deviation.

IV. Relevance to the Field of Human-Environment Interactions

A. How the results of your project are furthering the field of understanding and analyzing the use of climate information in decision-making

The current understanding of the use of climate information/forecast by agricultural producers has been based on a few surveys focusing on usefulness of forecasts in making agricultural decisions and on potential of using forecasts to improve production. Little attention has been given to the issues of why producers do or do not use forecasts in specific farming decisions, and how an intention of using climate forecasts forms through human psychological processes involving interactions among personality, personal interest and orientation to community, ability of understanding the forecasts, financial ability, and existing government policy. How economic and social environments affect these interactions in development of the intention and its execution? These fundamental questions are addressed in this study. Answers to these questions will further our understanding of decision-making related to use or not use climate forecasts and lead to identifying effective ways to improve the use of climate information in agricultural decision-making.

B. How this research builds on previously funded HDGEC research via other federal agencies

Please see I-D. Some of the projects founded by other federal agencies started earlier than this NOAA project. As depicted in that section these projects are collaborative and interactive and mutually benefiting one another.

C. How is your project explicitly contributing to the following areas of study?

1. **Adaptations to long-term climate change**

   In order to adapting to climate change, the society or a particular community, such as the agricultural community in the Great Plains, needs to not only know the climate change but also use the climate information in their planning and decision-making. Adaptation is established when climate information is integrated in short- and long-term plans and in decision behavior. Thus, the core issue in the adaptation to climate change is how to integrate the climate information in the decision behavior. This study will reveal the decision behavior of agricultural producers in the Great Plains, disclose how much climate information has been used in their decision-making, and identify ways to improve the use of climate information in decision behavior and hence more effective adaptation.

2. **Natural hazards mitigation**

   An effective mitigation of natural hazards is to "plan ahead." To plan ahead, we need to consider expected future hazardous conditions, e.g., droughts, floods, and tornadoes, and the probability for such conditions to occur, build this information in plans, and execute them accordingly. Again, the decision to build the information in a plan is a decision to use climate forecasts. How much do we use climate forecasts and information and how do we use them in planning? These questions need to be addressed in order to improve mitigation of natural hazards.

This study will address these questions and, by showing ways to improve use of climate forecasts and information, will lead to better mitigation methods.

3. **Institutional dimensions of global change**
   Findings and methods developed from this project will be useful to the National Drought Mitigation Center and the High Plains Regional Climate Center participating in this project. Through their activities the findings could influence governmental and institutional decisions related to climate change.

4. **Economic value of climate forecasts**
   Although a quantitative measure of economic value of using a particular climate forecast will not be calculated in this project, its results will show the bulk of economic value of forecasts. For example, Figures III-7 and III-8 show the expected value of long-term climate forecasts by agricultural producers in choosing best crops for a growing season and for plans to maximize crop revenue in marketing. These decisions involving using climate forecasts will bring economic values to the producers. By improving the use of climate forecasts this project will enhance economic values of climate forecasts to agricultural producers.

5. **Developing tools for decision-makers and end-users**
   This project will lead to improving forecasts' contents and formats to raise the frequency of using climate forecasts by agricultural decision-makers.

6. **Sustainability of vulnerable areas and/or people**
   The Great Plains is a vulnerable area for agriculture and the area's farming community and economy are particularly sensitive to climate change. Establishing a habit and skill of correctly using climate forecasts and information in planning and decision-making is an important strategy to sustain the community and economic development of the area.

7. **Matching new scientific information with local/indigenous knowledge**
   Nebraska is in a unique geographical location with large east-west gradient of precipitation and large north-south gradient of temperature. In this environment, both regional and local weather and climate information is important for decision-making. In this project, our understanding of agricultural producers' perception of local climate information, e.g., those produced by the High Plain Regional Climate Center, will help the Center improve both its local climate information and ways to deliver it to promote the use of the local information in decision-making.

8. **The role of public policy in the use of climate information**
   Findings of this project on concerns and obstacles affecting agricultural producers' use of climate forecasts and information will be useful for revising policies such that they can remove the obstacles and encourage use of climate forecasts and information in decision-making.

9. Socioeconomic impacts of decadal climate variability

While helping establish a habit and skill to use long-term (including decadal scale) climate forecasts and information, this project will help to bring the long-term climate change information into strategic planning, thus either enhancing the favorable climate impact on socioeconomic well being of regional societies or reducing adverse impacts of climate change on regional socioeconomics.

10. Other (e.g., gender issues, ways of communicating uncertain information)

A goal of this project is to improve expressing and communicating the uncertainties associated with climate forecasts and information and to help the end-users of the forecasts, e.g., the agricultural producers, to develop skills to correctly use the forecasts in their decision-making.

V. Graphics

A. Graphic depicting the overall project framework/approach

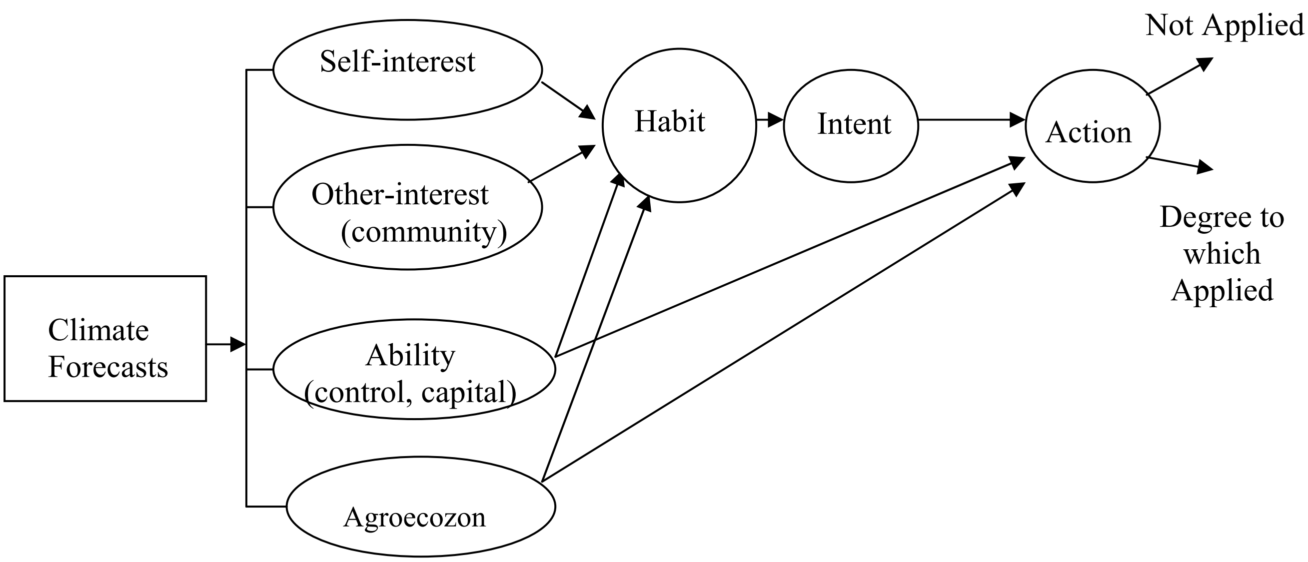

Figure V-1. Intent and action to adopt and apply climate forecast/information.

VI. Website address for further information

http://snrs.unl.edu/noaa-hdgc